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MAN AND HIS NERVOUS SYSTEM IN THE WAR. II

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THE GENERAL RESULTS OF INTERNAL ORGANIZATION

THROUGH the agency of these various kinds of organization, the activities of the organism are so coordinated or correlated that, under the usual conditions of existence, no one of the life processes outruns the others. No one process or reaction goes on unchecked or uncontrolled, but each process is regulated in conformity with the needs of the body. The organism looks after itself. This orderly coordination of internal activities of the plant or animal organism was, as referred to a few pages back, called physiological integration by Herbert Spencer. The point of view of the physiologist is that all internal processes of the organism go on for the good of the organism as a whole. As Haldane expressed it, the changes which occur in response to changing conditions are such as to perpetuate the life of the organism. This constitutes one phase of what Treviranus called adaptation—the property which, as Burdon-Sanderson believed, distinguishes living from non-living matter.

In setting forth the progress of physiology as consisting in the increase of our knowledge of the internal organization of the plant or animal body, one may see a justification of Burdon-Sanderson's earlier statement as to the proper field of physiology—"The action of the parts or organs in their relation to each other." The physiology of the past has been almost wholly concerned with the physiology of the individual, with only brief reference in a few of the texts, *e. g.*, Beaunis and Luciani, to the physiology of the species.

With the entrance of the physiology of the species into the problem, we must, I think, add something to the statement on the outcome of the processes in living matter. All the ordinary processes in individual living organisms which go on for the good of the organism may be regarded as egoistic activities, or, as some would express it, selfish activities. But when the point of view is shifted from the individual to the species, there is another group of activities which enters in, and which has reference to other individuals. This second group of processes,

since it has reference to other individuals, may be regarded as altruistic rather than egoistic. The continued existence of a species depends, therefore, first upon the successful outcome of the egoistic processes to the end that individual organisms may be present on the earth and, second, upon the successful outcome of the altruistic processes to the end that there may be new individual organisms upon the earth to take the place of those that die. There must be, therefore, a continual balance struck between egoistic and altruistic activities if the species is to survive. To anticipate a part of the discussion in later portions of this paper, we may say, also, that the new individuals must be somewhat better on an average, than the old if evolution is to occur. That evolution has occurred, there is now little doubt.

As a result of the study of the internal organization of living forms, we have gained certain ideas of the various processes or changes occurring in living organisms. Jost[17] summarizes these changes as: (1) Changes of form, including the phenomena of growth and development. (2) Changes of position, either of the organism as a whole or of its parts with relation to each other or to the organism as a whole; this includes all phenomena of movement. (3) Changes of matter and energy—metabolism in its widest sense.

THE ORGANISM IN ITS ENVIRONMENT

Until the organism comes into contact either with its environment or with other organisms, it can have little relation to other things, and, consequently, physiology as a science can have little relation to the great lines of scientific thought in general until it considers the relation of the processes of the regulation of the internal conditions of the organism to the external world. Evolution, heredity and variation, and man's mental reactions to the conditions of his environment are all matters of general biological, or even public, interest and we may inquire into the relation between physiology and these other lines of work. As a rule, the animal physiologist, as distinguished from the plant physiologist, has not considered his material from the point of view of organic evolution, and to a still greater degree, he has not considered how his body of fact will react upon the current conceptions of the process of evolution, either in the way of sharpening our ideas or of modifying them to bring them into line with what is known from the physiological or functional side of biology.

[17] "Vorlesungen über Pflanzenphysiologie," 2d., pp. 3–4, Jena, 1908.

There are certain large problems in biology which, by definition at least, belong to physiology, but which as a matter of fact do not at present form a subject of investigation by physiologists. Such, for instance, are the great questions of development and heredity, and the varied and important reactions between the organism and its environment included under the term ecology or bionomics.[18]

Yet, unquestionably, the body of fact on the functional organization of animals and plants is now sufficiently large and complete to exert an influence upon wider and more general aspects of biological thought.

The Influence of the Doctrine of Evolution upon the Development of Physiology

The doctrine of evolution has had an influence upon the development of the wider inductions of physiology in places where physiology and morphology have touched upon common ground. But the recognition of the influence of organic evolution upon the development of physiology has, on the whole, been more tardy and much less extensive than similar recognition in morphology. The science of morphology is, in fact, confessedly founded upon the doctrine of evolution, but such a statement can not yet be made about physiology. Claude Bernard included evolution as one of the fundamental properties of living matter, and Beaunis included evolution as one of the principles of physiology, but such statements have not been generally incorporated in the texts on physiology in the present century. The biologist must eventually follow the lead of the astronomer or the astrophysicist and the geologist and attempt the explanation of the evolution of plant and animal forms in terms of the underlying changes of matter and energy as the astronomer and the geologist are doing now.

A digression may be pardoned here. Claude Bernard not only saw the larger province of physiology, but he also saw the application of the fundamental principles of science to his own subject. The opinion of a neutral observer from the province of astronomy may be given here:[19]

The statue of Claude Bernard before the college must appeal to every scholar; for his "Introduction a l'étude de la médicine expérimentale," unfortunately veiled from workers in other fields by its medical title, is one of the classics of science. Here in the crystalline clearness of perfect French, devoid, in large part, of professional details, the general principles of scientific research are superbly presented. No investigator unfamiliar with this great work should leave it long unread.

[18] Howell, *loc. cit.*, p. 11.

[19] Hale, G. E., "Science and Learning in France," The Society for American Fellowships in French Universities, p. 11.

There have been times when the physiologist might stand in the presence of his fellows, as Cellini did in the studio of Francis I., and say: "I too am a scientist."

On the morphological side, the idea of evolution has influenced physiology in the development of our ideas of the circulatory, respiratory and digestive mechanisms. Many texts on physiology include brief surveys of the comparative anatomy and physiology of these systems, and there is now in the literature a considerable bulk of facts on the comparative physiology of these systems. But, on the whole, the comparative physiology is treated more from the morphological than the purely functional side.

The influence of evolution is shown also in the treatment of the nervous system. But here again the treatment of the comparative side of the central nervous system has been more morphological than functional. Edinger and von Monakow have shown that, considered morphologically, there are two nervous systems in the higher vertebrates. There is the primitive or phylogenetically older central nervous system to which Edinger has applied the term palæencephalon, present in the lower vertebrates and persisting in higher vertebrates. But higher vertebrates possess some nerve cell groups and fiber tracts which have appeared in the course of organic evolution, and been added to the palæencephalon as it exists in lower vertebrates. This phylogenetically newer portion is known as the neencephalon.

It is the phylogenetically newer portion, the neencephalon of Edinger, which is particularly related to the cerebral hemispheres, either as end stations for afferent fibers or as the site of origin of motor fibers. It follows that cerebral localization is possible in a high degree only when the neencephalon is developed in a high degree. Localization in other parts of the nervous system is probably related more to the palæencephalon than to the neencephalon.

The question of cerebral localization as well as localization in the nervous system generally has been a subject of controversy for more than four decades, and there is still no general agreement on many of the points concerned. There is little question that, morphologically, the anterior portion of the central nervous system—the brain—has undergone profound changes in the course of evolution. Steiner and others have supposed that there might be a shifting of function toward the anterior end of the nervous system corresponding to the change in structure. Gaskell emphasized the increasing importance to

the animal of the head in acquiring its experience. Goltz, however, opposed the idea of the shifting of function toward the brain and denied the validity of the theory of cerebral localization. Goltz stated his belief that the same segments of the nervous system—*i. e.*, the spinal cord, the medulla oblongata, the cerebral hemispheres and the rest—exercised essentially the same functions in all types of animals. There is no detailed and extensive cerebral localization in the frog and, on the basis of Goltz's view, there can be no more in man. Twenty years later, Edinger expressed an essentially similar view about certain portions of the nervous system. I am unable to see the validity of either Goltz's or Edinger's argument, but I have been repeatedly told that the error lies in my own way of thinking and not in any part of the Teutonic argument. I still adhere, however, to my views expressed ten years ago that the function as well as the structure of the central nervous system has undergone profound changes in the course of vertebrate evolution. I do not believe, as Goltz insisted, that the same structures in the nervous system of man necessarily have the same functions they exercise in the frog. Nor do I see that Edinger's view helps us much.[19]

Quite apart from those phases of the subject in which I have come into conflict with the weight of authority, I do not feel that the influence of the idea of evolution upon the general conceptions of physiology has been as great as it should have been.

The Influence of Physiology upon the General Conceptions of Evolution

The other phase of the question remains. What effect have the conceptions of physiology had upon the general trend of thought in evolution?

The contribution made by physiologists directly has not been large, but the application of some of the principles of physiology by biologists to the problems of evolution has been of greater extent. In recent years the plant physiologists have been attacking such problems as the effect of changes in the environment upon plants and we are now getting quantitative data on which to base our opinions. Perhaps a better way to put it is to say that we are supplanting mere opinion by statements of fact.

There is sufficient evidence from the side of physiology to show that there is a decreasing effect of the environment upon

[19] Pike, *Journal of Comparative Neurology*, 1918, XXIX., p. 485.

the internal physico-chemical conditions of organisms as successively higher types are studied. In more recent years it has been recognized that Herbert Spencer made a statement of considerable biological importance when he said the organism acquired an independence of the environment. Woods has emphasized this phase of the subject in "The Law of Diminishing Effect of the Environment" and Julian Huxley has presented the subject, partly from the point of view of the zoologist, partly from the point of view of the philosopher, in his "Individual in the Animal Kingdom." I have given elsewhere a survey of the mechanisms, considered from the point of view of the physiologist, by means of which higher animals have attained their independence of the environment.[20] I have also pointed out that this increasing independence of the environment or, in other words, the increasing rigidity of the internal organization of the organism, eventually leads to a limitation of the possibility of changes in the individual organism in the course of its lifetime.[21] From the lowest forms on up to the highest, there is an increasing rigidity of the physico-chemical organization which not only limits the effect of the environment on the organism, but which also limits the magnitude of internal changes that are compatible with continued life of the organism. Reichert has shown that changes of a physico-chemical nature constitute one of the processes of organic evolution. The conclusion follows, that, while rigidity of the internal physico-chemical organization may result in greater efficiency of the individual organism, it interferes with the progress of evolution in the individual. But Claude Bernard's statement that evolution is one of the characteristics of life seems to me essentially sound. The highly organized, efficient, but unchangeable organism dies and a new one takes its place. Efficiency demands its price.

The data accumulated by physiologists in the study of the chemical mechanisms of the plant and animal body form a necessary background for the study of the dynamic effects of changes in the environment. For until we know the constitution of the organism under standard conditions, we are not in a position to say what changes have been produced in that constitution or physico-chemical system by subjecting it to a different set of conditions.

The chemical mechanisms in the internal organization of

[20] Pike, F. H., and Scott, E. L., *American Naturalist*, 1915, XLIX., p. 321.

[21] *Journal of Heredity*, 1917, VIII., p. 195.

living forms exemplify Bergson's statement that "Life manifests a quest for individuality and tends to constitute systems naturally isolated, naturally closed." For the organism is a physico-chemical system of its own, and it tends to close itself more and more against the effects of the environment. But nowhere does the independence of the environment become complete.

The possibility of the effect of a change in the environment upon the organism is not limited to possibility of an effect upon the physico-chemical mechanisms. Des Cartes, in the seventeenth century, pointed out that the central nervous system is a mechanism capable of bringing about the coordination of the activities of the animal in response to a change in the environment.

The property of irritability is highly developed in nervous tissue, and in the higher animal organisms, we find developed at the periphery an elaborate series of receptors or sense organs whose general function is to lower the threshold of stimulation to a particular form of stimulus, or, in less technical language, to make the organism more sensitive to the manifestations of certain forms of energy in the environment. Some specific examples of these will be given further on in this paper.

Psychologists have taken up the problem of the reaction of the individual to those changes in the environment which affect the sense organs, and to which the individual responds by the exhibition of some phenomenon of behavior. Public interest in their results has been much greater than in the results on the organization of the nervous system, and the influence of the psychologists upon thought has been greater than that of physiologists. The reason for this is that the psychologist has considered the relation of the organism to the environment while the physiologist has not done so to an equal degree. But the fundamental basis for the explanation of the psychologist's results, upon which any rational interpretation of his facts must rest, is the organization of the central nervous system. Progress in psychology is, to this extent, dependent upon progress in the physiology of the nervous system.

It is sometimes a thankless task for a worker in one field to point out the indebtedness of workers in other fields. It is all the more gratifying, therefore, to be able to cite the acknowledgments of other workers of their interest, if not of their indebtedness; for when the acknowledgement is voluntary, the prospects of cooperation are greater, and most certainly the

students of the nervous system need to cooperate in the present state of science. In psychology, there are numerous instances of the manifestation of this interest. A recent example is that of Professor W. H. Burnham whose paper on "The Significance of Stimulation in the Development of the Nervous System"[22] emphasizes the relation of the organism to the environment and gives an account of the organization of the nervous system in terms somewhat different from those which I have employed.

An even stronger statement is that by Forel:

> Comparative Psychology is an as yet almost unexplored territory and but little understood, for want of approaching it by the best side, that is to say, by carefully made observations. It is involved either in metaphysical dogmas, or in shallow anthropomorphism which confounds inherited instinct and its automatisms with the plastic judgment of the individual, based upon memory and the association of memories or sensory impressions. Let us be thoroughly imbued with the truth that each species and even each polymorphic animal form has its special psychology, which should be especially studied, and which depends on the one hand upon the development of its muscles and senses, and on the other upon that of its brain.[23]

I may, then, plead the fundamental nature of the organization of the nervous system as a justification for any attempt to explain man's responses to certain changes in the environment from the point of view of physiology.

It has long been recognized in one way or another that the physiology of the nervous system can not be adequately studied without reference to the relation of the organism to its environment. This is clearly set forth by Professor C. J. Herrick in the opening chapter of his "Introduction to Neurology." Instincts have long had a fascination for biologists and I venture to quote here a statement from a French master which I have cited in another paper.[24]

> We may distinguish, in those attitudes and movements which are intended to express our intellectual and instinctive acts, and which are included under the generic term "gestes," between those which are bound up with organization and, as a consequence, are present in all men, in whatever condition, and those which have arisen and reached their perfection in a social state.
>
> The former are intended to express the most simple condition, the internal sensations as joy, pain, grief and the like, as well as the animal passions, through cries and the voice. One may observe them in the idiot,

[22] *American Journal of Psychology*, 1917, XVIII., p. 38.

[23] "The Senses of Insects," quoted by Rau, Phil and Nellie, "Wasp Studies Afield"; Princeton University Press, 1918.

[24] *Journal of Comparative Neurology*, 1918, XXIX., p. 487.

the savage, the blind from birth, as well as in civilized man enjoying all moral and physical advantages. These are native or instinctive responses.

Whitman[25] also recognized this essential relationship in his statement that "organization shapes behavior."

If, as I hope, I have been successful in showing (1) that physiology has great potentialities for the further study of large biological and human problems and (2) that it has not so far lived up to its promise, I have two things yet to do. We may consider first the reason why physiology has not fulfilled its promises and then make some attempt at the general fulfillment of the promise given in the introduction, to consider man's reaction to the general conditions of the war. As to the reason why physiology has had such a limited development, compared to its opportunities, I suspect German academic influence in great part. The grounds for this suspicion are found in the following quotation from Merz:[26]

> I must remind the reader here that though I use the word biological as denoting the more recent point of view from which all phenomena of the living world are being grouped and comprehended, and though the word seems first to have been used by a German, nevertheless, the arrangement of studies at the German universities has hardly yet recognized the essential unity of all biological sciences. They are unfortunately still divided between the philosophical and the medical faculties. It is indeed an anomaly, hardly consistent with the philosophical and encyclopaedic character of German research, that palaeontology, botany, zoology and anthropology, should belong to the philosophical, whereas anatomy, physiology and pathology are placed in the medical faculty. Eminent biologists and anthropologists, such as Schleiden, Lotze, Helmholtz and Wundt, have accordingly belonged to both faculties. To place biological studies on the right footing would require a mind similar to that of F. A. Wolf, who evolved out of the vaguer idea of humaniora the clearer notion of a science of antiquity, and who accordingly was able to convert the training school of teachers, the seminary, into a nursery of students of antiquity. Whether a similar reform in the purely scientific interests of the "science of life" which is now mostly cultivated for the benefit of the medical practitioner, can be effected in this age when practical aims are gradually taking the place of scientific ideas, is another question.

When we remember the date when this was written (1903) it will be seen that it was not mere war hysteria, but the well-considered opinion of a scholar, arrived at after long and careful study of the problem. For this very reason, it commands more respect and attention than it otherwise might.

The condition which Merz describes does not exist in Germany alone. Physiology, as it has been developed in America,

[25] "Animal Behavior," Marine Biological Lectures, Woods Hole, Session of 1893, p. 298, Boston, 1899.

[26] Vol. 1, p. 220.

largely under the influence of the German schools as I believe, has not concerned itself much with the relation between organism and environment. With little exception, American physiology has been a strictly subordinate subject in a polytechnicum, concerned more with those phases of internal organization which have a supposed immediate medical interest than with those which have a more general scientific interest, and dealing more with those aspects of the relation of the organism to the environment which may be comprised within the limits of the pharmacist's stock of drugs and the appliances of the hospital and the sanitarium than with the relations of organism and environment as they exist in nature generally. The technical aspects of physiology must, of course, be investigated and taught. I am inclined to believe that they should occupy an even larger place in the medical curriculum than they now hold. But these technical aspects should by no means comprise all of physiology. Chemistry and physics long ago passed from the control of medical faculties and began their course of development as independent scientific subjects. It would be interesting to speculate upon their probable present stage of development if they had remained under the exclusive control of either medicine or engineering.

If any insist that there have been no agencies which have tended to retard the progress of physiology, we have still to explain why it has not fulfilled the promise of development which it had in the days of Claude Bernard and the French School of his time. The field has been mapped out and, if there have been no retarding influences, the only alternatives appear to be that a part of the field is unworthy of being worked, or that no men of sufficient vision have appeared to work in all parts of the field, neither of which appears to be wholly reasonable.

The more general phases of physiology are now for the most part being studied in departments of zoology, particularly by the animal ecologists, and botany. The students of the effects of the environment on the organism have been, for the most part, less familiar than they should be, with the details of the internal functional organization of plants and more particularly of animals. The students of internal organization have too often cared but little or not at all for the relation between changes in the environment and possible changes in internal organization. Without the cooperation of workers along each of these lines, and others as well, it does not seem possible that physiology should reach its maximum usefulness to science in

general, and, through science, to the human race. It will not reach its greatest development as a science until more universities establish departments of general physiology, or extend existing departments for the study of the relationships of organism and environment in their widest phases.

It would not, however, be strict justice to German physiology to say, either that all of the tendency toward the restriction of physiology to the narrower field was of German origin, or that no attempts to raise the wider aspects of the science to a plane equalling in popularity and influence that on which the narrower view rests. Verworn, Rosenthal and others, following the leadership of Claude Bernard's classic volume, have presented the subject of general physiology in meritorious texts, and a journal devoted exclusively to general physiology has been published in German for some years past. The relative prominence of the German publications has even led to the neglect of some of the French works on the same subject.

There are indications, however, that the strictly medical side of physiology as it has been taught is no longer quite adequate to the demands of the medicine of the future. Even medical men are beginning to look around beyond the present boundaries of the curriculum. An earlier statement of my own that the physiologist would seem to be the best qualified person finally to decide upon questions of adaptation, and a further statement that the theory of organic evlution seems the best place for workers in every line of biology to bring their results for the inspection and criticism of others, has recently received gratifying support from a medical source. In his volume on the relation of Medicine to Evolution, Adami[27] remarks, that "these matters of adaptation and evolution have of necessity to be approached from the aspect of function and the dynamics of living matter, rather than from the point of view of cell statics." Haldane[28] has considered the relation of the organism to the gaseous environment in detail.

If, as has already been indicated, evolution is one of the properties of living matter, it falls within the province of the physiologist, and its mechanism is to be explained, just as the mechanism of other physiological processes is to be explained, on the fundamental basis of changes of matter and energy. That the task is one of surpassing difficulty, few will doubt, and that we shall quickly arrive at a solution of the problems few

[27] "Medical Contributions to the Study of Evolution," New York, 1918, p. 85.

[28] "Organism and Environment as Illustrated by the Physiology of Breathing," New Haven, 1917.

will hope. The best we can do is to continue work along these lines.

In industrial life too, there is the beginning of an idea that the conditions of work in factories and offices may affect the amount of work done in a day. The human organism becomes a human machine in industrial plants, and it would seem axiomatic that the student of its internal organism should be the one best fitted to study its operation under industrial conditions.[29]

I may here summarize the field of biology, and especially that of physiology by quoting again from the distinguished Briton, Burdon-Sanderson:[30]

> From the short summary of the connection between different parts of our science you will see that biology naturally falls into three divisions, and these are even more sharply distinguished by their methods than by their subjects; namely, Physiology, of which the methods are entirely experimental; Morphology, the science which deals with the forms and structure of plants and animals, and of which it may be said that the body is anatomy, the soul, development; and finally, Oecology, which uses all the knowledge it can obtain from the other two, but chiefly rests on the exploration of the endless varied phenomena of animal and plant life as they manifest themselves under natural conditions. This last branch of biology—the science which concerns itself with the external relations of plants and animals to each other, and to the past and present conditions of their existence, is by far the most attractive. In it those qualities of mind which especially distinguish the naturalist find their highest exercises, and it represents more than any other branch of the subject what Treviranus termed the "Philosophy of living nature."

What is true of animals is true in greater or less measure of Man. We may now pass on to the consideration of man in his relation to his social and political environment.

(To be continued)

[29] Lee, F. S., "The Human Machine and Industrial Efficiency," New York, 1918, good bibliography.

[30] *Loc. cit.*, p. 465.